Incision design in implant dentistry based on vascularization of the mucosa

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Abstract

Objectives: The delivery of an adequate amount of blood to the tissue capillaries for normal functioning of the organ is the primary purpose of the vascular system. Preserving the viability of the soft tissue segment depends on the soft tissue incision being properly designed in order to prevent impairment of the circulation. A knowledge of the course of the vessels as well as of their supply area are crucial to the decision of the incision. The aim of this study was to visualize the course of the arteries using different techniques, to perform macroscopic- and microscopic analyses, and to develop recommendations for incisions in implant dentistry.

Material and methods: The vascular systems of seven edentulous human cadavers were flushed out and filled with either red-colored rubber bond or Indian ink and formalin mixture. After fixation a macroscopic preparation was performed to reveal the course, distribution and supply area of the major vessels. In the area of the edentulous alveolar ridge specimens of the mucosa were taken and analyzed microscopically.

Results: The analyses revealed the major features of mucosal vascularization. The main course of the supplying arteries is from posterior to anterior, main vessels run parallel to the alveolar ridge in the vestibulum and the crestal area of the edentulous alveolar ridge is covered by a avascular zone with no anastomoses crossing the alveolar ridge.

Conclusion: The results suggest midline incisions on the alveolar ridge, marginal incisions in dentated areas, releasing incisions only at the anterior border of the entire incision line, and avoidance of incisions crossing the alveolar ridge.

Surgical disciplines are always confronted with the problem of cutting and therefore damaging healthy soft tissue in order to gain access to the area of interest in the human body. While the access requirements have not changed over time, the incision techniques have changed (e.g. laser [Mausberg et al. 1993; Bryant et al. 1998], electrosurgical knife [Mausberg et al. 1993; Sinha & Gallagher 2003], water scalpel [Siegert 2000] and piezosurgery [Shelley & Shelley 1986]. Irrespective of the applied technique, the surgical access must provide for:

1. optimal visualization of the key area;
2. problem-free expansion of the soft tissue;
3. mobilization of the overlying soft tissue to cover the surgical field;
4. no placement over bony defects or cavities;
5. sufficient vascularization of soft tissue;
6. minimum tissue damage;
7. assured wound healing;
8. minimum esthetic impairment and
9. good tissue covering.

Mucosal closure has to protect the bone, the implant or the augmentation material,
to establish a connection to the local supply systems as soon as possible, and to avoid infections or dehiscences.

The consequences of any incision must always be kept in mind. Unlike embryological wound healing, where scarless healing is possible [Gary & Longaker 2000], any planned incision or injury of the covering soft tissue after birth will result in scarring which differs from regular skin or mucosa in terms of esthetics, functioning or nutrition and may be a weak point in the future. Among many factors, vascularization has proved to be decisive for any kind of tissue regeneration [Arnold & West 1991; Endrich & Menger 2000]. Growth, maturation or reconstruction of the body are conceivable without unimpaired vascularization [Folkman & Shing 1992]. A knowledge of the course and of the supply area of the arteries is the basis for selection of the appropriate incision.

The aim of this study was to establish recommendations for incisions, based on reliable knowledge of the distribution patterns and course of the vascular system in the oral mucosa.

Material and methods

Two different techniques were used to demonstrate the macro- and micro-architecture of the arterial vascular system in seven edentulous human cadavers.

A separate description of the venous system was not undertaken because it follows the arterial pathways in most parts of the body.

Vascular corrosion cast

A total of 150 ml of red-colored rubber bond [MR Givul® Revultex, Heinrich Wagner, Böblingen, Germany] was injected into the external carotid arteries on both sides after flushing out the vascular system with streptolysin solution at a pressure of 200 mm Hg. The head was then immersion-fixed. This technique allows the demonstration and macroscopic evaluation of vessels ranging from small calibres up to a diameter of 200 μm. After solidification of the elastic substance, the specimens were frozen and cut in medio-sagittal direction. The vascular system of the maxilla and mandible was transected in the vestibular and palatal/lingual planes. The course of the vessels and their relationship to adjacent anatomic structures and tissues were documented in layers.

Indian ink injection

In a second attempt 4 ml of colored Indian ink and formalin (4%) mixture were injected into the facial, lingual and maxillary arteries after flushing out the vascular system with streptolysin solution passing through the capillary plexus. The colored areas of the mucosa were inspected, photographed and resected in the edentulous area of the alveolar ridge. After cleaning of the specimens according to the method of [Spalteholz 1911] microscopic evaluation of the microvascularization was carried out.

Macroscopic evaluation

Following macroscopic preparation, single arteries were identified and their position and relationship to adjacent structures and their course from the exit from the bone up to the capillary system were described. The ink-stained areas of the mucosa were assessed with respect to their extent and borders and were assigned as a supply area to one of the injected arteries.

Microscopic evaluation

The mucosa of the edentulous alveolar ridge was evaluated microscopically with respect to the distribution and orientation of vessels. Special emphasis was placed on the crestal area where vestibular and oral parts of the mucosa are in direct contact.

Results

After preparation, the color-marked main vessels were identified and their course and relationship to other tissues and structures described [Fig. 1]. After dissolution of the surrounding soft tissue the vessels were demonstrated directly on the underlying bony surface [Fig. 2]. The points of exit from the foramen and the anastomoses to other vessels were shown. The results of all cases are summarized in Fig. 3.

Vascular territories of the maxilla (Fig. 4)

In the posterior part of the maxilla the vestibular gingiva was supplied by branches of the infraorbital artery, and the palatal mucosa by branches of the descending palatine artery. Anteriorly, in the area of the premaxilla, the supply was based on the facial artery regarding the vestibular parts.
Vascular territories of the maxilla (Fig. 4)
The posterior lateral part of the alveolar ridge was supplied by the facial artery, and the anterior part by the inferior labial artery and in 50% additionally by the mental artery. In 73% of the cases the lingual mucosa was supported exclusively by the submental artery and in 27% additionally by the sublingual artery. Regarding the lingual supply there were overlappings of both sides, whereas overlapping was found in 20% of the cases in the vestibular part covered by the facial artery.

Microscopic evaluation of the alveolar mucosa (Fig. 7a, b)
The demonstrated gingival branches are arterioles or capillaries, which have the characteristics not of end-arteries but of net-arteries with numerous anastomoses. There is an almost avascular zone in the crestal area of the edentulous alveolar ridge. The descriptions can be summarized into three main vascularization characteristics:

1. The main course of the supplying arteries is from posterior to anterior.
2. These vessels run parallel to the alveolar ridge in the vestibulum most of the time, only gingival branches stretch to the alveolar ridge.
3. The crestal area of the edentulous alveolar ridge is covered by a 1–2 mm wide avascular zone with no anastomoses crossing the alveolar ridge.

Recommndations for the incision (Fig. 8 a–d)
Because of divergent dentitions and, esthetic zones, as well as different parts of the gingiva [marginal, propria, mucosa] it is necessary to define and distinguish different parts of the incision line. The three decisive areas are:

- the crestal part of the edentulous region,
- the bordering papilla in cases of partially dentated jaws,
- the area of the releasing incision at the anterior and posterior limit of the incision.

The midcrestal incision seems to be the ideal choice for the edentulous area of the planned implantation. Making the cut in the area of the avascular zone prevents the risk of cutting through anastomoses or cutting out avascular areas of the mucosa.

Fig. 3. Overview after macroscopic preparation of the arteries in the maxilla and mandible. The main courses, distributions and relations are demonstrated.

Fig. 4. Vascular territories of the maxilla. The colors show the supply areas of different arteries: blue – infraorbital artery, red – descending palatine artery, black – facial and infraorbital arteries, green – descending palatine and anterior superior alveolar arteries.

Fig. 5. Vascular territories of the mandible. The colors show the supply areas of different arteries: blue – facial artery, red – submental and sublingual arteries, black – inferior labial and mental arteries.

Crossing area on the edentulous alveolar ridge (Fig. 6a, b)
A visible vestibular–oral separation line between the two supply areas at the center of the edentulous segments was demonstrated in edentulous spaces, free-end situations and totally edentulous jaws.

Fig. 6. After Indian ink injection a vascular separation line is visible in the center of the edentulous alveolar ridge.
For esthetic reasons, only marginal incisions should be used in the frontal region. Releasing incisions in the vestibulum should be avoided because they will cut obliquely through defined esthetic zones and not at their borders. Releasing incisions should be carried out, if at all, only at the anterior border of the incision line to avoid cutting through the vessels coming from posterior to anterior. Trapezoid flaps with anterior and posterior releasing incisions are avoidable in most cases because the surgical field can be adequately visualized, and mobilization using incising of the periosteum can be achieved by anterior incision only.

If it is essential not to touch the marginal mucosa, an incision in the vestibulum parallel to the alveolar ridge with tunneling preparation is recommended.

The papilla will be included in the incision in the anterior maxilla and reconstructed using microsurgical techniques during preparation and wound closure. In the lateral or posterior segment or in the event of a single posterior tooth in a free-end situation the papilla can be left untouched by making the releasing incision in front of the papilla.

**Discussion**

The different factors to be taken into account when planning a mucosal incision include esthetic aspects, plastic-reconstruction potential and blood-supply requirements. In a defect situation, the focus is on criteria relating to plastic reconstruction (e.g., preparation and mobilization of local flaps for coverage or reconstruction purposes). Most flap preparation limitations are because of inadequacy of the supporting vascular system.

Esthetic aspects play a decisive role, especially in the anterior part of the maxilla. It is essential to make an incision only at the border of esthetic zones or areas and to avoid damaging, displacement or reducing local tissue, because any substitute tissue is distinctive in its color, consistency, and surface structure.

Among all planning principles, the vascular-nutritive principle seems to be the most important one. The vascular system at the margin of a wound represents the most important nutritional structure for survival and the basis for reliable wound healing and therefore must not be damaged under any circumstances (Arnold & West 1991; Endrich & Menger 2000; Filippi 2001).

Consideration of the vessels involved in any soft tissue incision should be based on the extent and boundaries of the areas of supply of single major vessels. The anatomic principle of the vascular territories referred to in the literature under the term 'angiosomes' (Taylor & Palmer 1987; Houseman et al. 2000). Evaluations of the vascularization of specific areas of the oral mucosa have also been carried out (Kindlova & Scheinin 1968; Mormann & Ciancio 1977; Piehslinger et al. 1991; Bavitz et al. 1994; Kerdvongbundit et al. 2003) but only few studies have referred to total assessment and a subdivision into angiosomes (Whetzel & Saunders 1997).

In agreement with the results of other study groups, the midcrestal incision in the edentulous area of the alveolar ridge seems to be indisputably the safest and most reliable method (Scharf & Tarnow 1993;
Cranin et al. 1998; Heydenrijk et al. 2000]. Incisions, which will repeatedly cross the alveolar ridge will create small mucosal areas with uncertain vascularization, leading to disturbed wound healing, bone resorption and mucosal necrosis.

If the covering soft tissue has to be extended, e.g., in cases of lateral or vertical augmentation, this can be achieved with a periosteal incision and broad undermining mobilization.

The creation of a trapezoid flap with an anterior and posterior releasing incision can be avoided in cases without the necessity of extended coverage of augmented sites because sufficient visualization and mobilization can also be achieved using one single releasing incision. To prevent accidental cutting into the vessels running from posterior to anterior in the jaws, it seems appropriate to place the releasing incision at the anterior border of the midcrestal incision.

The inclusion of the papilla adjacent to the edentulous area is controversially debated. Reports of shrinkage and loss of interproximal bone have led to recommendations for parapapillary incisions [line angle to line angle] [Gomez-Roman 2001; Velvar 2002]. These alternatives, designed for primary preserving of the papilla, will not allow unrestricted visualization of the lateral marginal bone and the adjacent tooth. In the event of augmentation, lateral mobilization of the gingiva is almost impossible.

The marginal incision including the papilla allows a complete overview of the entire edentulous alveolar ridge and exact placement of the implant equidistant from the neighboring teeth. This incision is recommended especially for esthetically problematic areas in the upper incisor region [Wachtel et al. 2003; Erpenstein et al. 2004]. Using microsurgical techniques for preparation of flaps and reconstruction of the papilla [Burkhartt & Hurzeler 2000], shrinkage can be avoided when the underlying alveolar bone is not reduced and the contact point of the prostheticodontic treatment is not too far from the alveolar bone [Tarnow et al. 2003].

From angiologic aspects the papilla is different from the adjacent edentulous alveolar mucosa because the papilla is supplied by vascular anastomoses crossing the alveolar ridge. This key point allows different incisions including or excluding the papilla. The decision has to be made individually, with aspects of esthetics and plastic reconstruction being taken into account.

Résumé

Fournir une quantité adéquate de sang aux capillaires pour un fonctionnement normal de l’organe est le but premier du système vasculaire. Préserver la viabilité du segment de tissu mou dépend de l’incision du tissu mou qui doit être effectuée de manière précise pour prévenir la détérioration de la circulation. Une connaissance de géographie des vaisseaux ainsi que de leurs aires de réserve sont essentiels pour la décision de l’incision. Le but de cette étude a été de visualiser les artères en utilisant différentes techniques afin d’effectuer des analyses tant macro- que microscopiques et pour développer des recommandations pour les incisions lors de la pose d’implants dentaires. Les systèmes vasculaires de sept cadavres humains édentés ont été vidés et remplis avec soit de l’encre de Chine ou une solution rouge et du formol. Après fixation une préparation macroscopique a été effectuée pour mettre en évidence le cours, la distribution et l’aire de réserve des principaux vaisseaux. Dans la zone du rebord alvéolaire édenté des spécimens des muqueuses ont été prélevés et analysés microscopiquement. Les analyses ont mis en évidence les principaux caractères de la vascularisation de la muqueuse. Le cours principal des artères converge de l’arrière vers l’avant, les vaisseaux principaux courent parallèlement au rebord alvéolaire dans le vestibule et l’aire creste des rebords alvéolaires édentés et sont couverts par une zone non-vascularisée sans anastomose traversant le rebord alvéolaire. Ces résultats suggèrent donc des incisions au milieu de la ligne du rebord alvéolaire, des incisions marginales dans les zones dentées, des incisions d’accès seulement dans la frontière antérieure de la ligne d’incision générale et l’abstention d’incision traversant la crête alvéolaire.

Zusammenfassung

Die Gestaltung der Inzision in der dentalen Implantologie aufgrund der Vaskularisierung der Mukosa


Resumen

Objetivos: El suministro de una cantidad adecuada de sangre a los capilares tisulares para el funcionamiento normal de un órgano es el propósito primario del sistema vascular. La preservación de la viabilidad del segmento de tejido blando depende en la incisión del tejido blando que debe estar debidamente diseñada en orden a prevenir mermas en la circulación. Un conocimiento del curso de los vasos al igual que del área de suministro es crucial para la decisión de la incisión. La intención de este estudio fue visualizar el curso de las arterias usando diferentes técnicas, para realizar análisis macro- y microscópicos, y desarrollar recomendaciones para incisiones en odontología de implantes.

Material y métodos: Se vaciaron los sistemas vasculares de 7 cadáveres humanos edéntulos y rellenados con pegamento de goma de color rojo o con una mezcla de tinta india y formalina. Tras la fijación se llevó a cabo una preparación macroscópica para revelar el curso, distribución y área de suministro de los vasos principales. En el área de la cresta alveolar edental se tomaron especímenes y se analizaron microscópicamente.

Resultados: Los análisis revelaron las principales características de la vascularización mucosa. El curso principal de las arterias de suministro as desde posterior a anterior, los vasos principales corren paralelos a la cresta alveolar en el vestíbulo y el área crestal de la cresta alveolar esta cubierta por una zona avascular sin anastomosis que cruce la cresta alveolar.

Conclusión: Los resultados sugieren incisiones en la cresta alveolar, incisiones marginales en áreas dentadas, incisiones liberadoras solo en el borde anterior de la línea completa de incisión, y evitar las incisiones que cruecen la cresta alveolar.
References


Kleinheinz et al. Incisions in implant dentistry


